Submitted by the expert of ETRTO

Informal document **GRBP-70-20**
(70th GRB, September 11-13, 2019,
agenda items 6 (d) and (e))

WET GRIP TEST METHOD IMPROVEMENT for Passenger Car Tyres (C1)

Overview of Tyre Industry and ISO activities

GRBP - 70th session

Geneva
September, 2019

- **BACKGROUND / RECAP**
- **TRAILER method revision – RECAP and UPDATE**
- **VEHICLE method revision**
- **TIMELINE**

- **BACKGROUND / RECAP**
- TRAILER method revision – RECAP and UPDATE
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CURRENT REGULATORY FRAMEWORK

ISO test method for PSR wet grip is thr reference for several regulations (EU, UN and worldwide)

ISO 23671:2015
Passenger car tyres — Method for measuring relative wet grip performance -- Loaded new tyres
UNDER REVISION

TYPE approval - UN R117.02 – Test method in Annex 5(A)
(minimum requirement on WET grip for homologation)

TYRE LABELLING
Europe EC 1222/2009* - Test method in Annex V (*Reg. 228/2011*)
… but also Brazil, Korea, Japan, …
***Note: revision of EU label will directly refer to UN R117 for wet grip test**

GTR16
Global Technical regulation

This standard is under revision: the experience accumulated so far by the Industry and by the EU Member States Authorities indicated an opportunity for developing further improvements on the accuracy of the test method

REPRODUCIBILITY OF THE CURRENT WET GRIP TEST

The current wet grip test method allows the **NECESSARY FLEXIBILITY in terms of testing conditions worldwide**: *possibility to test using different tools (vehicle/trailer), on different tracks (wide friction range for tracks), and in different periods of the year (wide temperature range).*

When the test was firstly developed, it appeared to grant both **a good repeatability** (same test conditions = same test results) and a good reproducibility (different test conditions = same grade).

Anyhow the **reproducibility of the test is not in line with the initial evaluations**.

In other words, when different set of testing conditions (within the allowed ranges) are adopted to test the same tyre, the same wet grid index might not be always granted.

Note

This problem was identified in the ***Final Report on the Review study on the Regulation (EC) No 1222/2009 on the labelling of tyres (March 2016)***

Following the experience accumulated after the implementation of EU label Reg. 1222, **Tyre Industry progressively recognized the problem and indicated opportunities for improvements** in the same Review Study

TYRE INDUSTRY / ISO COLLABORATION

Following preliminary collaboration among EUROPE, USA and JAPAN Tyre Industry, the revision of the existing ISO 23671:2015 for PSR was launched last Sept 14th, 2017;

An ISO (global) "technical table" is currently in place:
The WET GRIP Working Group (**TC31/WG12**) was established with the aim to

By priority

1. **Improve the reproducibility** of the current ISO,

2. **Try to keep on average similar wet grip indexes values and ratings as current test procedure**

3. Drive the **global standardization & promote harmonization worldwide**

Status update (2018, August)
Draft International Standard registered

TYRE INDUSTRY and ISO TECHNICAL ACTIVITIES

Step 1 – Identification of the parameters affecting the dispersion of the test

✓ *completed*

Step 2 - 3 Round Robin Tests using TRAILER methodology

✓ *Completed*
Total of 37 tires - 1163 results!
16 different test sites/trailer in EU (ETRTO), Japan (JATMA) and USA (USTMA)

Step 3 – 1 Round Robin Tests Using VEHICLE methodology

✓ *Completed*
tests In EU (ETRTO)

Step 1 – Identification of the parameters affecting the dispersion

The **parameters having an influence on the variability of test method** were listed exhaustively
The most impacting the reproducibility of the test were identified:

1. **Methodologies (TRAILER / VEHICLE)**

2. **Conditioning (stabilization) of tyre prior testing**

3. **Wet Track - Friction & Temperature**

4. **Tyre typologies & corresponding correction equations**

- BACKGROUND / RECAP
- **TRAILER method revision – RECAP and UPDATE**
- VEHICLE method revision
- TIMELINE

TYRE BREAK-IN (CONDITIONING)

Tyre Break-In (conditioning) was identified as an important source of variability

Current standard

*For tyre break-in, **two braking runs** shall be performed under the load, pressure and speed as specified*

Not enough!

New proposed approach:

*The tyres **should be stabilized in performance prior to testing**, **which means that no evolution of the μ_{peak} /BFC values in test runs should be detectable**; in any case there will be an ex-post verification according to clauses specified in [the test procedure]**

In all cases, tyre designed tread depth and designed tread block or rib integrity shall not change significantly with break-in, which means the pace and "severity" of the break-in needs to be carefully controlled to avoid such changes.

*[***paragraph "Validation of tests results"** – improved requirements on the Coefficient of Variation (CoV) of the μ_{peak} /BFC values of both reference and candidate tyres and on the evolution of the reference tyre (SRTT) during the test cycles]*

Note: "how" operationally stabilizing the tyre (on road driving, drum,…)is left to each company, being also dependent on internal practices and tyre constructions.

TRACK GRIP

- In the current method, the grip of the track can be controlled with one of two criteria

  BPN **[42-60]** or μ SRTT14” **[0,6-0,8]**

  Anyhow there is **no correlation between the 2 criteria** → this point is an important source of variability between different test centers.

  Also the reference tyre **SRTT14’’ will be discontinued**

- **SRTT 16’’ will be used NOT ONLY AS REFERENCE TYRE, BUT ALSO FOR TRACK VALIDATION IN PLACE OF [SRTT 14 or BPN]**
  - ✓ **Replacement of SRTT14 and discontinuation of BPN measurement**
  - ✓ **A source of variability eliminated**

- **agreement for friction range μ SRTT16” [0.65 ; 0.90]**

TYRE TYPOLOGIES / Track Temperature

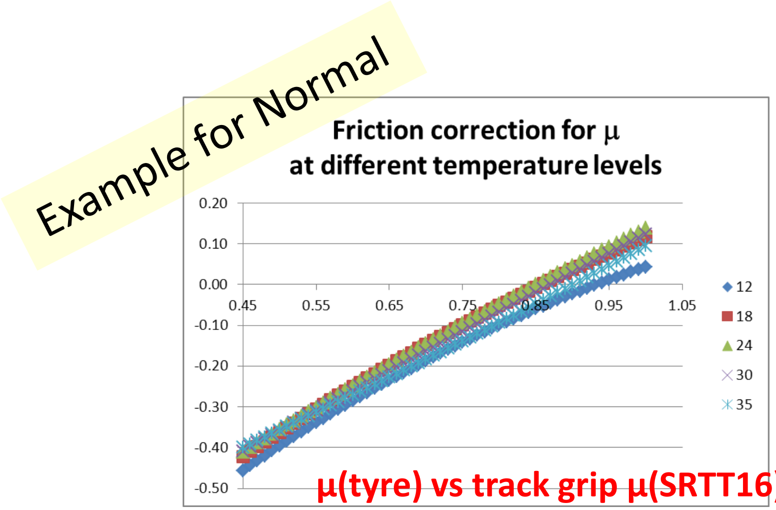
3 different typologies of tyres should be treated differently within the wet grip test procedure

R117 category of use / markings	Normal -	Snow M+S - <u>not</u> 3PMSF	Snow for use in severe snow conditions M+S and 3PMSF	
				
Commercial name	SUMMER	<u>USA</u> ALL SEASON	<u>EU</u> ALL SEASON	WINTER
	Normal tires are designed to perform best in warm weather and are **not typically used at low temperature**	intended to perform across most temperature ranges. They are designed also for use in lower temperatures but not at the level of a Severe Snow (Winter) tire. They **can operate at higher temperatures**, without the typical limitations of Severe Snow (Winter) tires	guarantee the min snow traction of a Severe Snow (Winter) tire. They are **also designed to operate at higher temperatures**, without the typical traction limitations of Severe Snow (Winter) tires	Severe Snow tires are designed to perform best in severe cold weather conditions and are **not typically used during extended warm weather conditions**
WET GRIP test CONDITIONS	T ref = 20 12-35 ˚C	T ref = 15 5-35˚C	T ref = 10 5-20 ˚C	

each tyre typology has its own behavior vs friction & temperature

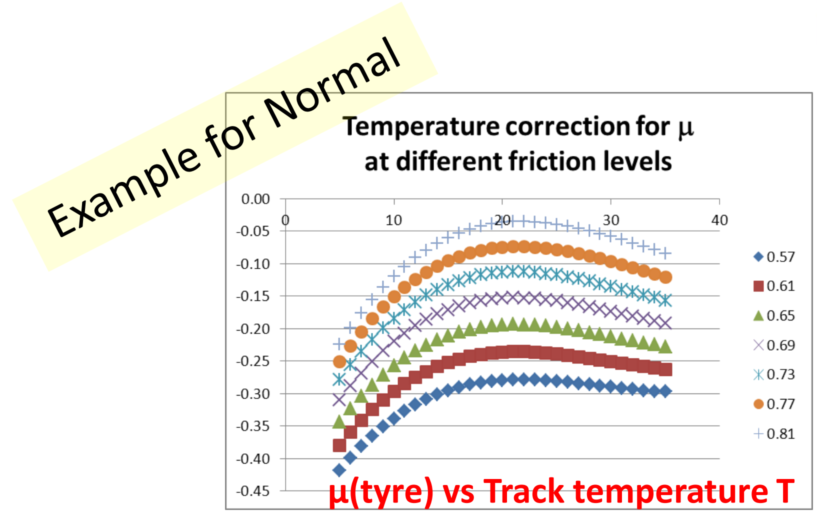
→specific /different correction formulas and coefficients shall be applied

CORRECTION FORMULAS



μ(tyre) vs track grip μ(SRTT16)

~ linear → $a\ \Delta\mu$



μ(tyre) vs Track temperature T

~ quadratic → $b\ \Delta T + c\ \Delta T^2$

The grip of the track has a strong influence

The MTD (Mean Texture Depth) has also a minor influence

$d\Delta MTD$

The temperature (especially the low temperature for normal tyres) has also an influence (even if lower than the grip)

$$NEW \quad G(T) = K_{trailer} * [\mu_{test} - (a\ \Delta\mu + b\ \Delta T + c\ \Delta T^2 + d\Delta MTD)]$$

where:

$\Delta T = T_{test} - T\ ref$

$\Delta\mu = \mu_{SRTT16} - 0.85$

$\Delta MTD = MTD - 0{,}8$

a, b, c, d : different depending on tyres typologies

K-trailer: minimizes the difference in average current vs future procedure for TRAILER

CORRECTION FORMULAS

Dataset 2014-2017 = RRT ETRTO-JATMA-USTMA TRAILER
1163 results of 37 different tires (18 “Normal”, 9 “M+S”, 10 “3PMSF”)

- **Correction coefficients [a, b, c, d] minimize the dispersion of the tests results** for each tyre typology

Tyre sidewall marking	t_0	a	b	c	d
Neither M+S marking nor 3PMSF marking	20	0.99757	0.00251	-0.00028	0.07759
M+S marking without 3PMSF marking	15	0.87084	-0.00025	0.00004	-0.01635
3PMSF marking	10	0.67929	0.00115	-0.00005	0.03963

- **K-trailer: minimize the difference in average current vs future procedure for TRAILER**

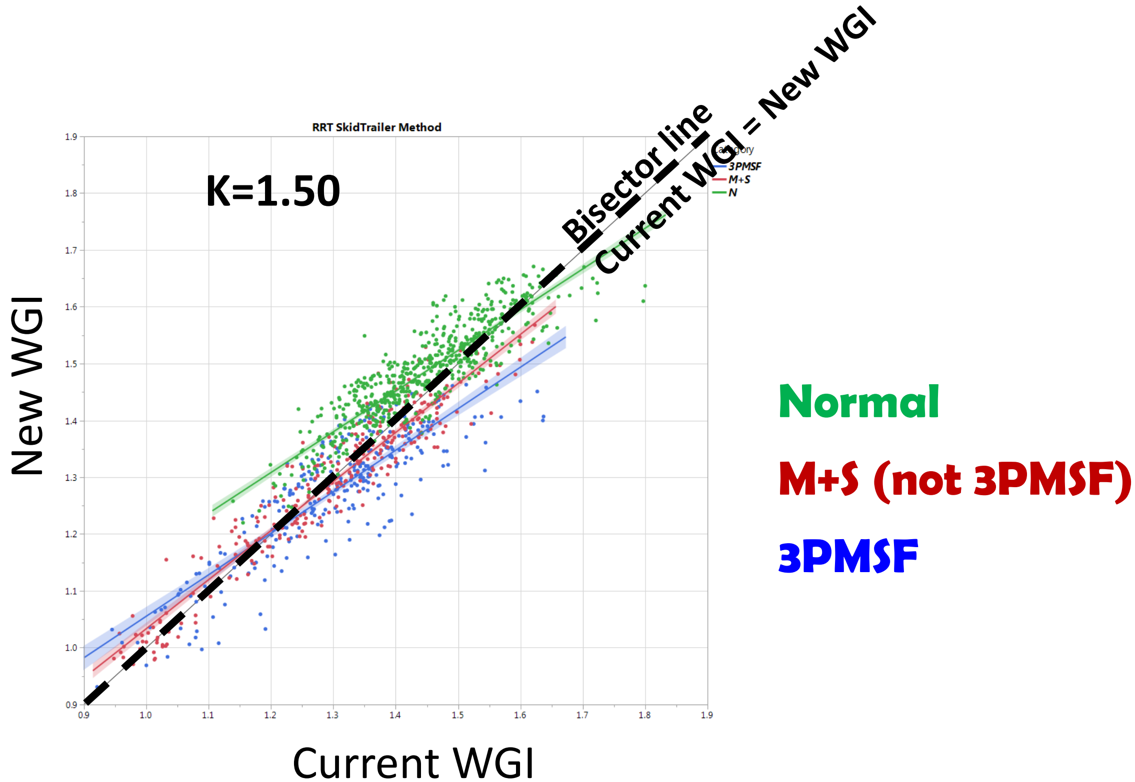
Method: Least Squares

Calculation

S = Σ (WGI proposed – WGI current) ^{2} → S minimization: K trailer = 1.502

K trailer = 1.50

ADDITIONAL CONSIDERATIONS



<u>On average</u>:

- All points (Current WGI / new WGI) well distributed across the bisector line **(= overall gap is minimized)**

<u>On average, for each tyre typology (Normal, M+S only, 3PMSF)</u>

- similar WGI values as current procedure

<u>On the single tests results</u>

- The proposed procedure grants more stability (vs tests conditions) than current procedure: consequently possible differences in WGI (new vs current) <u>on single tests</u> results depend on the specific test conditions

- BACKGROUND / RECAP
- TRAILER method revision – RECAP and UPDATE
- **VEHICLE method revision**
- TIMELINE

Step 3 – Round Robin Tests Using VEHICLE methodology

Some of - **but not all** - the technical findings on trailer can be automatically transposed to vehicle methodology.

ETRTO (EU only) performed dedicated test campaign on vehicle:

1. to **compare the variability of both TRAILER and VEHICLE methodologies**
2. to check the **correlation between the two modified** methods (both methods should give same Index)

- **Technical findings on trailer directly applicable also to vehicle method**
  - **Tyres typologies** and permitted **temperature range**
  - **Stabilization** of tyre performance prior testing

- **Dedicated technical analysis for vehicle method**
  - Usage of two vehicles with a “control” tyre (**Bridge test**)
  - **Track friction description**
  - **corrections formulas** (tailored for vehicle)
  - …other… e.g. Vehicle, Tyres Inflation Pressure adjusted depending on actual axle load

VEHICLE – “BRIDGE TEST”

Currently used when size of the candidate tyre differs significantly from SRTT

VEHICLE 1		VEHICLE 2		
Control Vs SRTT	+ bridge	Candidate Vs Control	→	Candidate Vs SRTT

Bridge test increases significantly the dispersion

Possibility of bridge test is ELIMINATED

Even if it is recognized that it will be not possible to test on vehicle the full range of existing sizes (Load indexes).

For the “extreme” sizes trailer method shall be used.

VEHICLE – "FRICTION RANGE"

- **<u>IN CASE OF TRAILER</u>** → **Elimination of BPN and $\mu_{SRTT14''}$**

  Friction Range $\mu_{SRTT16''}$ [0.65 ; 0.90]

- **<u>IN CASE OF VEHICLE</u>**

  - Not possible to measure the $\mu_{SRTT16''}$ [on trailer]
  → agreed to use the corresponding parameter on vehicle: BFC (SRTT16'')

  correlation **$\mu_{SRTT16''}$ [on trailer] <-> BFC(SRTT16'') [on vehicle]**
  depends on both vehicle and trailer used

On average

µSRTT16" [on trailer] = (0.65-0.90) corresponds to BFC(SRTT16'') [on vehicle] = (0.57-0.79)

VEHICLE – "CORRECTION FORMULAS"

Same formulas as trailer: 4 "optimized terms but tailored for vehicle

$$G(T) = K_{vehicle} * [BFC_{test} - (a'\ \Delta BFC + b'\ \Delta T + c'\Delta T^2 + d'\Delta MTD)]$$

Correction coefficients [a, b, c, d] minimize the dispersion of the tests results for each tyre typology

Tyre sidewall marking	t_0	a'	b'	c'	d'
Neither M+S marking nor 3PMSF marking	20	0.99382	0.00269	-0.00028	-0.02472
M+S marking without 3PMSF marking	15	0.92654	-0.00121	-0.00007	-0.04279
3PMSF marking	10	0.72029	-0.00539	0.00022	-0.03037

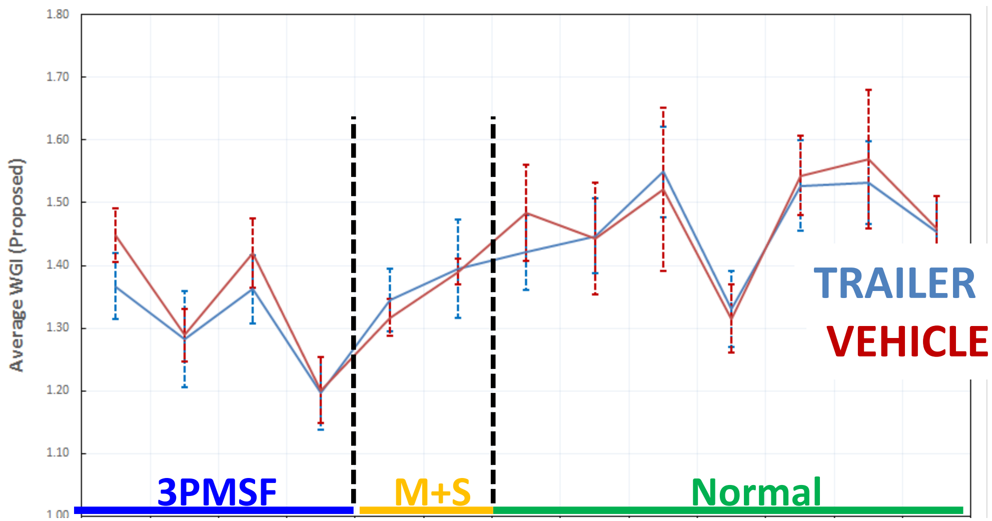
K-vehicle: minimize the difference new procedure for TRAILER vs new procedure for VEHICLE.

Using ETRTO dataset of the tyres tested on both vehicle and trailer

$$S = Sum\ of\ Diff = \sum_{i=1}^{13} (WGI_{SkidTrailer} - WGI_{Vehicle})^2$$

→ *K-vehicle = 1,87*

VEHICLE – ADDITIONAL CONSIDERATIONS



- The possible gap between trailer and method is minimized.
- No method (trailer or vehicle) provides systematically higher or lower WGI results

Proposed amendment of paragraph 4 of ISO 23671:2015

For the evaluation of the wet grip index (G) of a candidate tyre, the wet grip braking performance of the candidate tyre is compared to the wet grip braking performance of the reference tyre on a straight, wet, paved surface. It is measured with one of the following methods:

- vehicle method consisting of testing a set of tyres mounted on a commercialized ***vehicle****;*

- test method using a ***trailer*** *or a tyre test vehicle equipped with the test tyres.*

In case of verification of the wet grip index (G) the same test method [i.e. Trailer / Vehicle] used for its declaration shall be used.

TRAILER & VEHICLE – IMPROVEMENT BY THE NEW FORMULAS

		TRAILER RRT	VEHICLE RRT BRIDGE excluded
Total number of data		1163	319
Number of candidate tyres	Normal	18	9 (7 same as trailer)
	M+S	9	2 (2 same as trailer)
	3PMSF	10	7 (4 same as trailer)
Number of testing companies		17 EU + USA + JPN	6 EU
Weighted Standard deviation CURRENT formula	Normal	0.083	**0.103**
	M+S	0.077	**0.047**
	3PMSF	0.088	**0.059**
Weighted Standard deviation NEW formula	Normal	**0.065 (- 22%)**	**0.089 (-14%)**
	M+S	**0.060 (- 22%)**	**0.025 (-46%*)**
	3PMSF	**0.060 (-32%)**	**0.051 (-13%)**

** Improvement to be considered jointly with the number of candidate tyres*

- BACKGROUND / RECAP
- TRAILER method revision – RECAP and UPDATE
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- **TIMELINE**

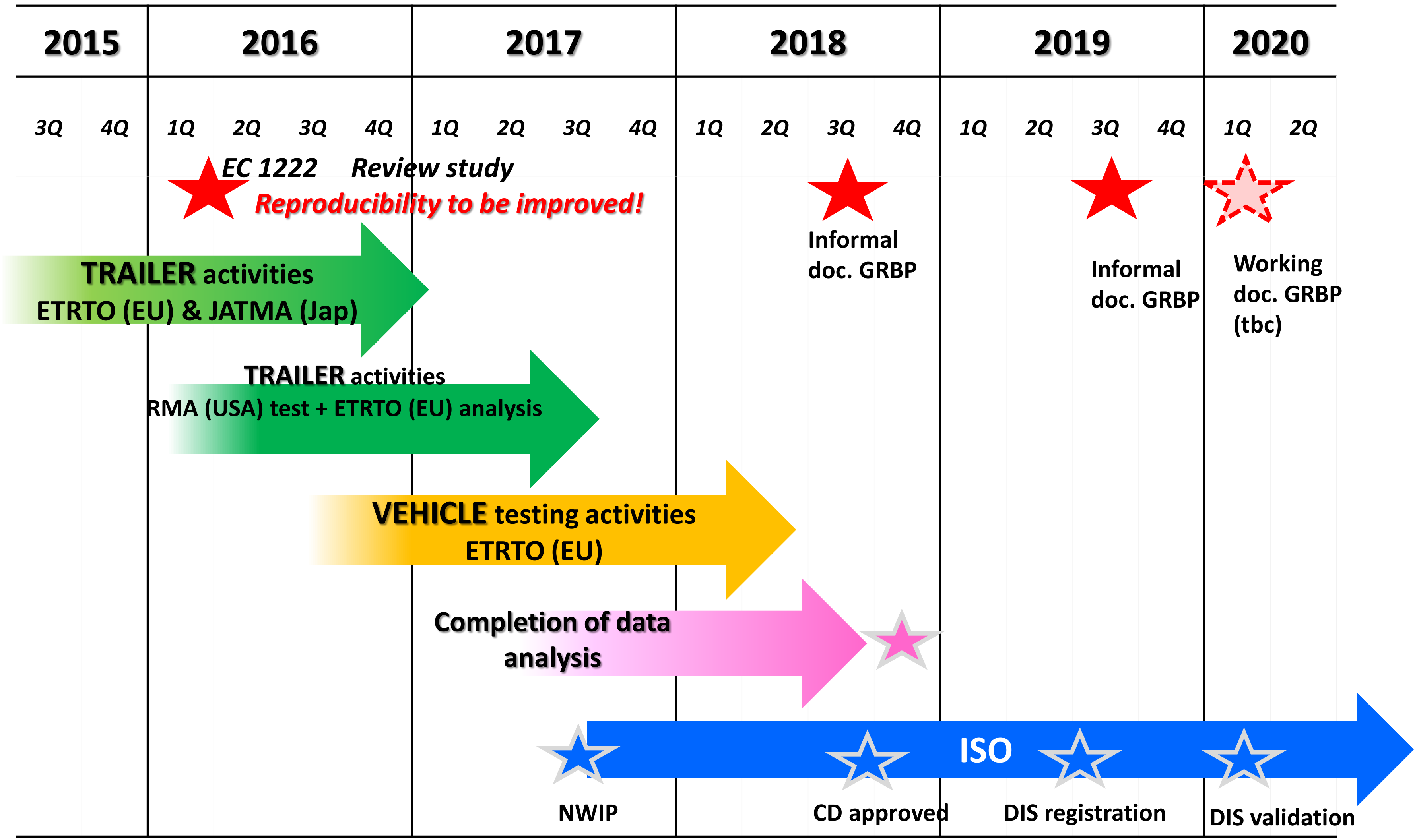
TIMELINE

FROM PREVIOUS INDUSTRY MEETING / GRBP INFORMAL DOC

ACTIVITIES ENLARGED AT ISO level

- Robust technical approach

- Worldwide Harmonization



APPENDIX

CURRENT WET GRIP TEST - TECHNICAL PRINCIPLES

For the calculation of the wet grip index of a candidate tyre, the wet grip performance of the **candidate tyre is compared to the <u>reference tyre ASTM SRTT 16”</u>** (**S**tandard **R**eference **T**yre **T**est).

→ Thus it is a **COMPARISON TEST**.

The wet grip index can be measured with one of the 2 following methodologies (today considered as equivalent):

TRAILER

using a trailer towed by a vehicle

1 tyre mounted on a specific tool

OUTPUT

peak braking force coefficient (µ peak)

highest value of the ratio braking force / vertical load

VEHICLE

using an instrumented passenger car

1 set of 4 tyres mounted on a commercialized vehicle

OUTPUT

Average Deceleration (AD)

measured during braking

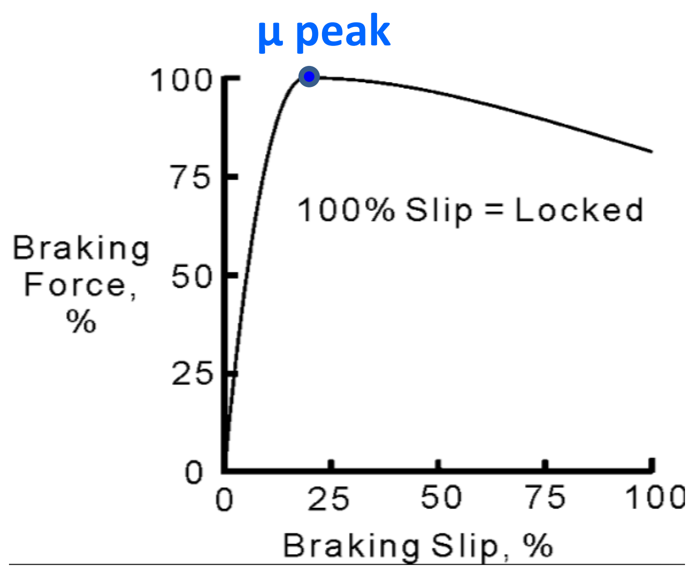
WET GRIP TEST METHOD - CURRENT REGULATORY FRAMEWORK

TRAILER METHODOLOGY

The tyre to be tested is fitted on a specific position for measurements (test position)

The brake in the test position is applied maintaining the specified speed (65 km/h) and the specified Load (depending on the Load Index of the tyre) until test-tyre lock-up

The ratio braking force / vertical load is acquired in real time: the highest value of this ratio provide the wet grip performance of the tyre.
It is called **tyre peak braking force coefficient (µ peak)**



WET GRIP TEST METHOD - CURRENT REGULATORY FRAMEWORK

VEHICLE METHODOLOGY

An instrumented passenger car, equipped with an Antilock Braking System (ABS).

Starting with a defined initial speed, the brakes are applied on four wheels at the same time to activate the ABS

The **average deceleration** AD is calculated between two pre-defined speeds (80→20km/h).

Braking Force Coefficient → BFC = AD / g

VEHICLE METHODOLOGY USING CONTROL TYRE SET (BRIDGE TEST)

Where the candidate tyre size is significantly different from that of the reference tyre (SRTT), a direct comparison on the same instrumented passenger car may not be possible.

In that case the comparison between a candidate tyre and a reference tyre is obtained through the use of a control tyre set (so called “bridge”) and two different instrumented passenger cars.

CAR 1
Control
Vs
SRTT

+

CAR 2
Candidate Tyre
Vs
Control

→

Candidate Tyre
Vs
SRTT

CURRENT WET GRIP TEST - APPLICABLE REFERENCE TYRES (ASTM)

SRTT 16’’

ASTM F2493 P225/60R16

*Must be used as **reference tyre** to determine the relative wet grip performance of the candidate tyre*

SRTT 14’’

ASTM E1136 P195/75R14

Will be discontinued

*It **can be** used to verify / certify **track friction properties** (one of the 2 possible methods)*

CURRENT WET GRIP TEST - TECHNICAL PRINCIPLES

Mathematical corrections are applied to align the results when the tests are performed in different conditions: i.e. different test locations (tracks) or different weather conditions (temperatures).

$$G(T) = \frac{\mu_{candidate\ tyre}}{\mu_{SRTT16}} 1{,}25 + A \cdot (Temp - T_0) + B \cdot (\mu_{SRTT16} - \mu_0)$$

This ratio is a **raw index** of the measured friction of the candidate tyre vs the SRTT16'' at the tests conditions (Temp, μ_{SRTT16})

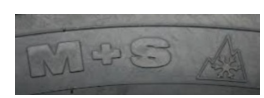
Linear correction in temperature to estimate the value of the index at the reference temperature T_0

Linear correction in friction to estimate the value of the index at the reference friction (track) μ_0

The mathematical corrections (coefficient A and B) depend on category of use of the candidate tyre:

- **Normal Tyres**

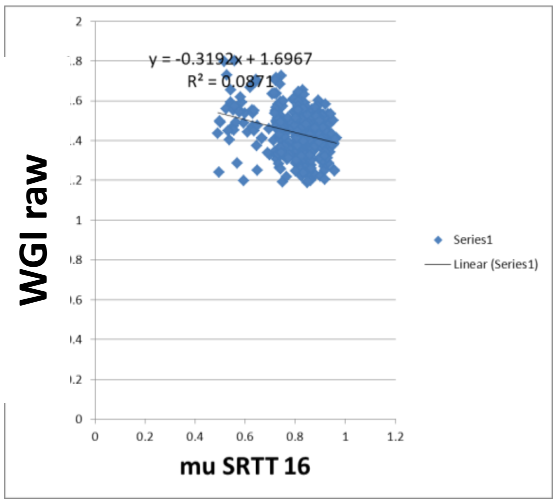
- **Snow Tyres (all tyres marked M+S**, including the tyres marked also 3PMSF)

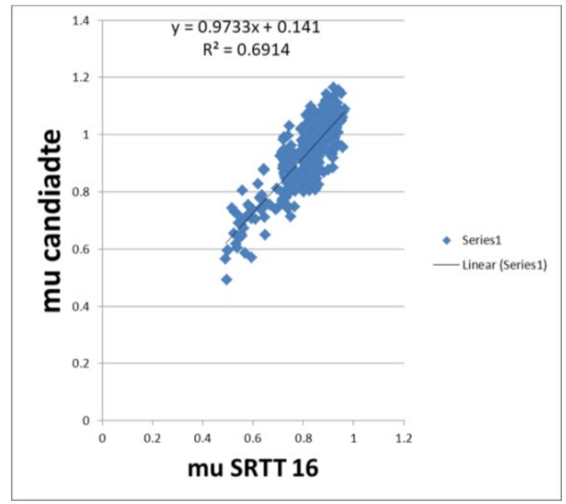


CORRECTION FORMULAS – BASIC IDEA

$$\text{WGI raw} = \frac{\mu_{candidate\ tyre}}{\mu_{SRTT16}}$$

$$\mu_{candidate\ tyre}$$





No relation between Ratio WGI raw and μ-SRTT16

Correction should NOT be applied to WGI raw (as done today)

Evident linear relation between μ-cand and μ-SRTT16 (track friction)

Correction should be applied directly to μ-cand tyre

TRAILER METHOD – mu Ref

Reference mu = 0.85 (ref. conditions) unchanged vs current ISO / R117 test method

➔ **keep *consistency between this revised edition and previous edition of this standard***

- Method : for μ_{Ref} in {0.75, 0.80, 0.85}, re-optimize a, b, c, d coefficients and re-evaluate dispersion

μ ref = 0.85

Paramètres pour calcul : proposed WGI		Summer	All-Season	Winter
μref		0.85	0.85	0.85
Tref		20	15	10
MTDref		0.8	0.8	0.8
dmu	a	0.9975691	0.8708228	0.6792844
dI	b	0.0025130	-0.0002537	0.0011512
dT^2	c	-0.0002756	-0.0000361	-0.0000522
~~dmu^2*dI~~	~~d~~	~~0~~	~~0~~	~~0~~
dMID	e	0.0775940	-0.0163497	0.0396333

	Summer	All-Season	Winter
Weighted StdDEV	0.06491	0.05593	0.05739
R^2	0.85153	0.88809	0.82840
Dispersion	2.43530	0.37681	0.39371

μ ref = 0.80

Paramètres pour calcul : proposed WGI		Summer	All-Season	Winter
μref		0.8	0.8	0.8
Tref		20	15	10
MTDref		0.8	0.8	0.8
dmu	a	0.9975729	0.8708343	0.6792880
dI	b	0.0025130	-0.0002537	0.0011512
dT^2	c	-0.0002756	-0.0000362	-0.0000522
~~dmu^2*dI~~	~~d~~	~~0~~	~~0~~	~~0~~
dMID	e	0.0775816	-0.0163521	0.0396305

	Summer	All-Season	Winter
Weighted StdDEV	0.06491	0.05593	0.05739
R^2	0.85153	0.88809	0.82840
Dispersion	2.43530	0.37681	0.39371

μ ref = 0.75

Paramètres pour calcul : proposed WGI		Summer	All-Season	Winter
μref		0.75	0.75	0.75
Tref		20	15	10
MTDref		0.8	0.8	0.8
dmu	a	0.9975775	0.8708437	0.6792907
dI	b	0.0025130	-0.0002536	0.0011511
dT^2	c	-0.0002756	-0.0000362	-0.0000522
~~dmu^2*dI~~	~~d~~	~~0~~	~~0~~	~~0~~
dMID	e	0.0775848	-0.0163538	0.0396284

	Summer	All-Season	Winter
Weighted StdDEV	0.06491	0.05593	0.05739
R^2	0.85153	0.88809	0.82840
Dispersion	2.43530	0.37681	0.39371

Conclusion : **NO significant evolution of coefficients (< 1.0E-05), neither on dispersion or WStdDev**

VEHICLE METHOD – OTHER POINTS

Vehicle

- Age of the car < 5 years
- mechanical conditions according to car manufacturer recommendations
- no alert from ABS (e.g. lights warnings).
- No substantial modification of the vehicle & specifically no modification of the braking system

Tyres Inflation Pressure *(front axle tyres)*

- differentiation standard load and XL (same as trailer)
- adjusted by a formula:
based on actual load of the vehicle + load transfer during braking (+ 30%~)

ISO 23671:201x - TIMELINE

✓ **New Project approved (TC31 plenary meeting)**	**2017, May**
✓ WG12 - Kick-off meeting, **Working Draft**	**2017, Sept**
✓ ISO WG12 WebEx's	2017, Oct → March
✓ **ISO WG12 meeting (Washington), CD agreed**	**2018, April**
✓ **CD submittal for ballot**	**2018, June**
✓ **CD approved with technical comments**	**2018, August**
✓ **DIS** registered (**submittal for ballot**)	2019, June
✓ **DIS validation - Text publicly available**	
✓ IS publication	2020, May [Deadline]

We are here

DIS registration should be prior working document at UN to grant alignment ISO – R117

ISO CD 23671:201x – BALLOTS RESULTS

No disapprovals,
12 approval votes
5 approval votes with comments.
3 abstention

Answers to Q.1: "Do you approve the circulation of the draft as a DIS?"		
13 x	Approval	Belgium (NBN) Canada (SCC) China (SAC) Finland (SFS) France (AFNOR) Germany (DIN) Korea, Republic of (KATS) Netherlands (NEN) Russian Federation (GOST R) Spain (UNE) Ukraine (DSTU) United Arab Emirates (ESMA) United Kingdom (BSI)
4 x	Approval with comments	Italy (UNI) Japan (JISC) Thailand (TISI) United States (ANSI)
0 x	Disapproval	
3 x	Abstention	Austria (ASI) India (BIS) Sweden (SIS)